Application of Rapid Prototyping Methods to High-Speed Wind Tunnel Testing

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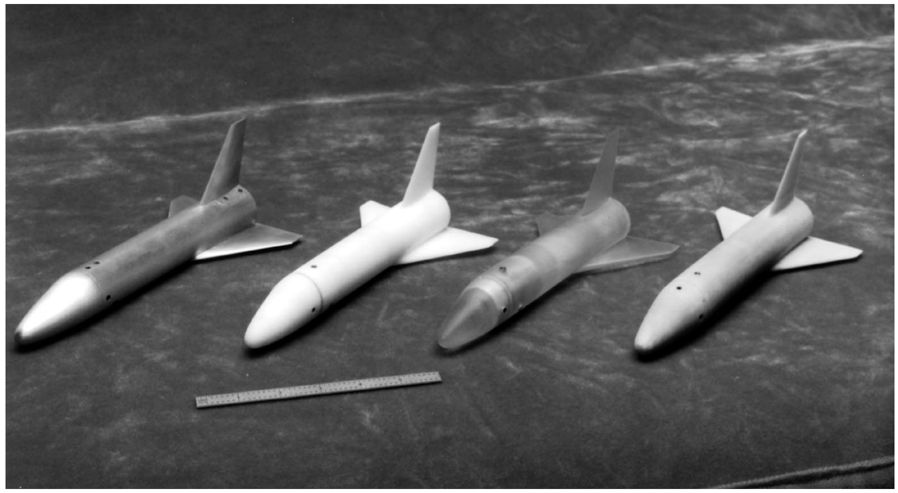

FIGURE 62.—Models used in rapid prototyping wind tunnel model study. Left to right: SLS, SLA, FDM-ABS, Al.

The aerodynamic characteristics of a vehicle are among the initial inputs in the design studies for future launch vehicles. These initial studies can be more accurate if high-fidelity aerodynamic information is available for the configurations under consideration. The quick turnaround normally required for these design studies along with cost precludes wind tunnel testing's availability for early design phases. Using rapid prototyping (RP) methods and materials to fabricate wind tunnel models has resulted in a quick turnaround capability via wind tunnel testing to provide higher-fidelity aerodynamic characteristics early in the initial design phases.

A study undertaken at MSFC's 14-in trisonic wind tunnel, funded as Center Director Discretionary Fund project 96–21, has shown that rapid prototyping methods and materials can be used to fabricate wind tunnel models of sufficient quality to produce satisfactory aerodynamic characteristics over the subsonic, transonic, and supersonic Mach ranges for limited configurations.

This study was undertaken to determine if rapid prototyping methods could be used in the design and manufacturing of high-speed wind tunnel models in direct testing applications. It was also done to determine if these methods would reduce model design/fabrication time and cost while providing models of high enough fidelity to provide adequate aerodynamic data and of sufficient strength to survive the test environment. Rapid prototyping methods utilized to construct wind tunnel models were fused deposition method (FDM) using both ABS plastic and polyetherether ketone (PEEK) as materials; stereolithography (SLA) using the photopolymar SL-5170 as a material; selective laser sintering (SLS) using glass reinforced nylon as a material; and laminated object manufacturing (LOM) using both plastic and wood as materials. The models produced that were of sufficient quality, FDM-ABS, SLA, and SLS were tested. These configurations were tested at subsonic, transonic and supersonic speeds, Mach 0.3 to Mach 5.0. A wing/body/tail configuration was chosen for this study. A comparison of results from models constructed using these rapid prototyping methods was made with results from a standard machine-tooled metal model constructed of aluminum. The plan was to determine if the aerodynamic characteristics of a generic vehicle would be effected by surface finish or other material properties. Also studied were the ease of manufacture and the wearability of the parts as compared to a standard metal wind tunnel model.

The results from this study showed relatively good agreement between the SLA model, the metal model with a replacement FDM-ABS nose and the metal model for the majority of operating conditions, while the FDM-ABS data diverged at higher loading conditions. Data from the initial SLS model showed poor agreement due to problems in post processing, which resulted in a different configuration than the other models. The data from the second SLS model tested showed good agreement with the other models. It can be concluded that rapid prototyping models show promise in preliminary aerodynamic development studies at subsonic, transonic, and supersonic speeds.

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Sponsor: Center Director's Discretionary Fund

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Ken Cooper is a materials engineering technician in the materials lab responsible for the operation and development of the FDM rapid prototyping process. He received an associate's degree in mechanical engineering from Wallace State College in Hanceville, AL.